APPLICATION

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TITLE: LINKAGE MECHANISM PROVIDING A VIRTUAL PIVOT AXIS FOR HAIR REMOVAL APPARATUS WITH PIVOTAL HEAD

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LINKAGE MECHANISM PROVIDING A VIRTUAL PIVOT AXIS FOR HAIR REMOVAL APPARATUS WITH PIVOTAL HEAD

Cross-Reference to Related Applications

This application claims priority under 35 U.S.C. § 119(a) from European Patent Application No. 02 022 221.2, filed on October 1, 2002.

Field of the Invention

The present invention relates to a linkage mechanism for a hair removal appliance, such as a powered or "dry" shaver or epilator, having a head rockably mounted on a body, and to such hair depilation apparatus. The term "hair removal appliance" may herein alternatively be referred to by the generic designation "depilation appliance" understood to include such species of hair-removing appliances as shavers and epilators. The invention also relates to a method of mounting a component, e.g. a head, for rocking about a virtual pivot axis.

Background

A dry shaver having a rockable head is known. The rocking of the shaver head facilitates good contact between the shaver head and the user's skin during shaving.

WO 93/12916 (U.S. Pat. 6,098,289 (Wetzel et al.)) discloses a shaver having a head rockably mounted on a shaver body by means of first and second linkage mechanisms at respective ends of the head. Each linkage mechanism comprises a pair of transverse link members and a pair of vertical link arms pivotally mounted on the head and depending therefrom. Each arm is mounted on the shaver body by means of the transverse link members pivotably attached to the link arms at respective ends and to the shaver body at a central pivot axis lying in a common plane of symmetry of

the first and second linkage mechanisms. The resulting four-bar linkage permits the head to rock about a virtual pivot axis located above its points of physical attachment to the link arms. This arrangement is a symmetric parallelogram, with the congruent pivot locations all lying in parallel lines.

Further linkage mechanisms of this type are described in US-A-5,704,126 (Franke et al.), 5,159,755 (Jestädt et al.) and US-A-4,797,997 (Packham et al.).

It is known in the field of dry shavers, e.g. in those distributed widely in the United States and Europe by the company Braun GmbH under the trade designations "Flex Integral" or "Synchro", to have the shaving head mounted on a pin bearing defining a pivot axis about which the head travels in an arc of about +/- 24 degrees either side of a rest position.

Four bar linkages have also been proposed to generate a virtual pivot axis and/or a side-to-side swivel axis in wet razors as in US-A-6,115,924 (Oldroyd). Reference may also be made to GB-A-1,460,732 (Terry et al.) which discloses a four bar box-like structure arranged parallel to the longitudinal axis of the cutting head of a wet razor.

Other four-bar linkages in wet razors are known from US-A-5,535,518 (Althaus), which purports to describe a parallelogram linkage in which each of two transverse links can buckle at a bend joint to unload a wet razor cartridge, and from US-A-5,953,824 (Ferraro et al.), which discloses a linkage whose longitudinal arms have slots which are cammed by motion relative to fixed pins on the housing as the base transverse link rocks from side to side, in order allegedly to maintain a relatively constant distance between the razor head mounting pins.

As mentioned above, an advantage of the four bar linkage mechanism of the type known from WO 93/12916 is that, as described in more detail hereinafter, a virtual pivot centre may be produced well above the points of attachment of the vertical side members to the shaving head. In fact, the virtual pivot may be located above, at or even below skin level, in dependence upon the height of the transverse link members, typically in the

form of pivoting triangles or bell crank links. This may be achieved without the need for a physical upper pivot location. However, a disadvantage of the mechanism is that the two vertical side members have to be arranged essentially parallel to the vertical plane of symmetry of the mechanism. In other words, the three points of attachment of each arm to, respectively, the rocking head, the first transverse link member and the second transverse link member lie on a straight line parallel to the plane of symmetry. Applicant has recognized that the resulting mechanism is relatively bulky and cannot be accommodated in a slim housing.

Summary of the Invention

According to one aspect of the invention, there is provided a linkage mechanism for a hair-removal appliance having a head carrying at least one hair removal member and mounted on the appliance body for rocking about a virtual axis generated by the linkage, said linkage mechanism mounted on a housing body and comprising: a pair of spaced support arms for pivotable attachment to the head at first and second pivot axes, said first and second pivot axes being spaced by a first distance; a first transverse link member pivotably mounted on said body for rotation about a third axis and being pivotably attached to each of said support arms at fourth and fifth pivot axes spaced by a second distance less than the first distance; and second and third transverse link members pivotably mounted on the body at respective first ends thereof and being pivotably attached at respective second ends thereof to respective ones of said support arms at sixth and seventh pivot axes, said first, second, third, fourth, fifth, sixth and seventh axes being mutually parallel.

A particularly compact arrangement is achieved when said sixth and seventh pivot axes are spaced by a third distance less than said first distance. Here, some further possibilities exist: either the third distance is less than the second distance, or *vice versa*. Also, this third distance could be of equal magnitude as the second distance.

Ergonomic design freedom is maximized when said respective first ends of the second and third transverse link members are pivotally mounted on the body at eighth and ninth pivot axes which are spaced apart, and parallel to said first and second axes (see e.g. Fig. 14). Vertical compactness is optimized when a plane perpendicular to said parallel axes intersects said third, eighth and ninth axes at spaced points forming an isosceles triangle. It is also possible for said eighth and ninth axes to be colinear, which may simplify construction by reducing the number of components. In a symmetrical arrangement, said third, eighth and ninth axes and said virtual axis all lie in a common plane.

Constructional simplicity is achieved when the distance between said first and sixth axes equals the distance between said second and seventh axes (see e.g. Fig. 2).

In certain circumstances, an asymmetric construction may be preferred, in which the distance between said first and sixth axes is greater than the distance between said second and seventh axes (see e.g. Fig. 8).

It is preferred that the distance between said first and fourth axes equals the distance between said second and fifth axes (see e.g. Fig. 2, Fig. 8).

Here a symmetrical arrangement may preferably be achieved when the distance between said first and sixth axes is less than the distance between said first and fourth axes (see e.g. Fig. 2, Fig. 11).

Alternatively, another compact arrangement is achieved when the distance between said first and sixth axes is greater than the distance between said first and fourth axes (see e.g. Fig. 17, Fig. 20). Although this will generally increase the vertical height of the mechanism, it may minimize the lateral width.

Other advantages of the present invention lie in the capacity of the linkage arrangement to permit a very large arc of rocking motion in proportion to the relatively slender handle or body in which the linkage is accommodated.

Preferably, there are first and second spaced linkage mechanisms supporting the head. While it is preferred to use this linkage to pivotally mount a hair removal appliance (generally, "a depilation appliance") constructed as a powered or "dry" shaver, and this embodiment is discussed extensively herein, one or more of such linkages can also be used to pivotally support a hair removal appliance constructed as an epilator head which removes hair by plucking (e.g. U.S. Pat. 5,611,804 (Heintke et al.)).

According to another aspect of the invention, there is provided a linkage mechanism for carrying a powered hair removal apparatus, e.g. a dry shaver or an epilator, which comprises a five-bar linkage pivotally supporting a hair removal head ("depilation head") for rotation relative to a housing about a virtual pivot axis. In a preferred embodiment, there are two spaced support arms which are pivotally connectable to a hair removal head; a first common transverse link member pivotally mounted on the housing body and pivotably attached to each of the support arms; and second and third stabilizing links pivotably mounted on the body at respective first ends thereof and being pivotally attached at respective second ends thereof to respective ones of said support arms. In such an embodiment, the hair removal head is not kinematically required as part of the "five-bar" linkage. When the second and third stabilizing links are pivoted at their respective first ends to the housing body, these second and third links are movable relative to one another. In preferred embodiments the two spaced support arms are not parallel to one another. In preferred embodiments a dry shaving head and an epilator are interchangeably connectable to the linkage or to an intermediate supporting head member connectable to the linkage, as generally described in U.S. Pat. 5,611,804 (Heintke et al.), the disclosure of which is hereby incorporated by reference.

According to another aspect of the invention, the hair removal head itself kinematically forms one of the links of the five-bar linkage carrying a powered depilation apparatus, e.g. a dry shaver or an epilator, wherein the hair removal head is pivotally supported for rotation relative to a housing

about a virtual pivot axis. In such an embodiment, the five-bar linkage is determined by two spaced support arms which are pivotally connected to the depilation head; a first common transverse link member pivotally mounted on the housing body and pivotably attached to each of the support arms; and at least one stabilizing link pivotably mounted on the body at a first end thereof and pivotally attached at a respective second end thereof to just one of said support arms. An additional transverse stabilizing arm may optionally be provided, for example to be more robust under load or to stabilize the support arms in the event the depilation head were detached.

In the immediately foregoing two embodiments, the support arms could even be parallel with one another, but each of these aspects of the invention still allows for compact arrangement of the handle to provide a relatively large arc of travel at the head, for example the one or more transverse links do not necessarily have to be mounted parallel to the common transverse link, or be the same size, or even have its pivot axis connected to the housing body between the two support arms; that is, there is significant design freedom in the spatial placement of the one or more transverse link(s) since each one does not interconnect between two support arms.

According to a further aspect of the invention, there is provided a method of mounting a component, e.g. a head carrying at least one hair removal member mounted, for rocking about a virtual axis, the method comprising the following steps: pivotably attaching a pair of spaced support arms to the head at first and second pivot axes, said first and second pivot axes being spaced by a first distance; pivotably mounting a first transverse link member on a body for rotation about a third axis and pivotably attaching the first link member to each of said support arms, at fourth and fifth pivot axes spaced by a second distance less than the first distance; and pivotably mounting second and third transverse link members on the body at respective second ends thereof and pivotably attaching the second and third link members at respective second ends thereof to respective ones of said

support arms at sixth and seventh pivot axes spaced by a third distance, said first to seventh axes being mutually parallel.

For a better understanding of the invention and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings.

Brief Description of the Drawings

FIG. 1 is a side view of a shaver head mounted for rocking movement on a shaver body according to a first embodiment of the invention, with the head pivoted to one side;

FIG. 2 is a side view corresponding to Figure 1, with the head in a neutral mid position;

FIG. 3 is a perspective view of the shaver head and mechanism of Figures 1 and 2;

FIG. 4 is a side view, corresponding to the view shown in Figure 2, of a second embodiment of the invention;

FIG. 5 is a side view corresponding to that of Figures 2 and 4, of a third embodiment of the invention;

FIG. 6 is a side view of the embodiment of Figure 5 with the head pivoted to one side;

FIGS. 7 to 9 show a schematic side view of a further linkage mechanism according to the invention;

FIGS. 10 to 12 show a schematic side view of a further linkage mechanism according to the invention;

FIGS. 13 to 15 show a schematic side view of a further linkage mechanism according to the invention;

FIGS. 16 to 18 show a schematic side view of a further linkage mechanism according to the invention;

FIGS. 19 to 21 show a schematic side view of a further linkage mechanism according to the invention;

FIGS. 22 to 28 show schematic views of linkage mechanisms according to embodiments of the invention, in which dimensions are indicated;

FIG. 29 shows a flow chart of a design method;

FIG. 30 is a diagrammatic side view of a prior art shaver head mounted on a linkage mechanism to permit pivoting of the head, with the head shown in a pivoted position to one side;

FIG. 31 is a diagrammatic view corresponding to Figure 30 with the head shown in a neutral untilted position;

FIG. 32 is a view corresponding to Figures 30 and 31 with the head pivoted to the other side;

Fig. 33 is a view corresponding to Figure 1, where an epilator head is mounted to the linkage in place of a shaver head;

Fig. 34 is a side view of the linkage arrangement of Figure 33 with the epilator head in a neutral mid position;

Fig. 35 is a perspective view of the epilator head and mechanism of Figures 33 and 34;

Fig. 36 is a side view of a shaver head mounted for end-to-end rocking movement according to another embodiment of the invention, with the head pivoted down at one end;

Fig. 37 is a side view corresponding to Fig. 36 with the head in a neutral mid position; and

Fig. 38 is a perspective view of the shaver head and mechanism of Figures 36 and 37.

Description of operation known from prior art

The linkage arrangement known from WO 93/12916, which is hereby incorporated by reference, will be described in more detail with reference to Figures 30, 31 and 32. Each of Figures 30, 31 and 32 shows a rockable head RK mounted on a shaver body in a manner to permit the head to be rocked from a central position, shown in Figure 31, to either the right hand side, shown in Figure 30, or the left hand side, shown in Figure 32. The

head RK will carry two or more foil-type shaving units. The rocking movement of the shaver head is achieved by means of a parallelogram linkage. The shaver head RK is mounted on the upper ends of two pairs of vertical side members 71 and 72, one pair of side members being provided at each end of the shaver, and only one side being shown in Figures 30, 31 and 32. At each end of the shaver, the pair of vertical side members 71 and 72 constitutes, in combination with transverse link members 73 and 74, a four bar mounting linkage. Each of links 73 and 74 constitutes a bell crank lever.

The bell crank levers 73 and 74 are pivoted at respective pivot points 77 and 78 to fixed points of the shaver frame. These fixed points of the shaver frame are located on a central plane 75 of the linkage mechanism, this plane forming a plane of symmetry when the mechanism is in the neutral position shown in Figure 31. Through this construction, a virtual pivot axis 76 is produced well above the points of attachment of the vertical side members 71 and 72 to the shaver head RK. In fact, the virtual pivot axis 76 may be located on, above or below skin level in dependence upon the size of the pivoting triangles or bell crank links 73 and 74, and indeed, approximately spaced as far above the attachment points as the height of a triangular shaped bell crank 73 between its connection points 82, 85 and its pivot location 77. This may be achieved without the need for a physical upper pivot location.

In addition to this advantage of free location of the virtual pivot axis, this method of mounting the shaver head provides a single, solidly linked foil frame assembly which is capable of supporting a multiplicity of foils, for example three foils or more. In addition, by the use of the upper virtual pivot axis, the tendency of the individual foils to pivot, during shaving in a manner leading to undesired shaving on the side of the foil, can be eliminated.

Each of the vertical side members 71 and 72 is attached to the remainder of the mechanism at three pivot axes. For example, side member 71 is attached to the rocking head RK at axis 81, to the transverse link

member 73 at axis 82, and to the transverse link member 74 at axis 83. Similarly, the second vertical side member 72 is attached at axes 84, 85 and 86 respectively.

Applicant herein has recognized that in order to function correctly, the pivot axes 81, 82 and 83 have to lie in a common plane parallel to a similar plane containing the pivot axes 84, 85 and 86. Each plane is moreover parallel to the central plane of symmetry 75. If, as seen in this side cross-sectional view, a line connecting pivots 81, 82, 83 were not parallel to a similar line connecting pivots 84, 85, 86, the mechanism would jam. As a consequence, the width of the linkage mechanism is essentially determined by the spacing between the axes of attachment 81 and 84 to the rocking head RK. Applicant herein has recognized that this is a disadvantage if it is desired to make the linkage mechanism more compact, for example to produce a slim housing.

In the cross-sectional view of linkage arrangement shown in Figures 30, 31 and 32, the axes of attachment 77, 82 and 85 of the upper transverse link 73 form a triangle which is congruent to the triangle formed by the axes of attachment 78, 83 and 86 of the lower transverse link member 74.

Detailed Description of Preferred Embodiments

Several embodiments of the present invention will be described in the following.

In the present invention, the constraint, for example, that the linkage be nearly as wide as its attachment location to the shaver head, is no longer necessary. The present invention employs an upper transverse linkage arrangement which is not congruent with the lower transverse linkage portion but which nevertheless generates a virtual pivot axis to permit rocking movement of the head of a dry shaver. The embodiments of the invention employ a five bar linkage comprising a main transverse link, two lateral support arms and two transverse stabilizing links. This permits a wide range of possible positions of the virtual pivot axis and also gives the designer the ergonomic freedom to package a large head with multiple shaving units together with a relatively thin and skinny handle.

In the conventional parallelogram linkage, the centres of rotation of the transverse links lie in a plane which is usually coincident with the vertical plane of symmetry of the shaver. In contrast, in some of the illustrated embodiments of the present invention, the transverse stabilizing links have inboard pivot locations which are spaced laterally away from one another. In further preferred embodiments, at least one of these pivot locations, or preferably both, are spaced from the imaginary vertical plane of symmetry of the linkage mechanism.

Referring to the drawings in more detail, Figure 1 shows a rocking head 1 mounted on a shaver body 2, schematically shown, by means of a linkage mechanism 3 at each end of the shaver, the mechanism at only one end being shown in Figures 1 and 2. Alternatively, only one such linkage mechanism could be provided, for example, at one end. Each linkage mechanism 3 comprises a pair of vertically extending support arms 4 and 5 pivotably mounted to the head 1 at pivot axes 12 and 11 respectively. The head 1 carries, in this embodiment, three shaving units 31, 32 and 33. Units 31 and 32 are short-hair cutters, whilst unit 33 is a long hair cutter. The units

are better shown in Fig. 3, and are preferably of the type disclosed in U.S. Patent 6,098,289 (Wetzel et al.), which is hereby incorporated by reference.

At the lower end of the support arm 5 is provided a support member 18 which is riveted to the support arm 5 by means of rivets 19, 20 and 21. A similar support member 22 is riveted to the lower end of the support arm 4.

A main transverse link member 6 is pivotably mounted on a housing frame 2 at a pivot axis 17 and has two limbs or mounting ends pivotably connected to the support members 18 and 22 (also referred to as connecting links) by respective film hinges allowing pivoting about axes 15 and 16. The main transverse link may be referred to as a common link since it interconnects both support members.

Two stabilizing transverse link members 7 and 9 are also provided. An upper support member 23 is riveted to the shaver body 2. The transverse link members 7 and 9 are each pivotably connected to the upper support 23 by respective film hinges allowing pivoting about axes 8 and 10. Thus, the locations at which the stabilizing link members, preferably at the upper part of the mechanism, are connected to the housing frame are spaced apart. The link members 7 and 9 are also pivotably connected to the first and second lower support members 18 and 22 by further film hinges 13 and 14 respectively.

As discussed above, where the depilation appliance head kinematically forms one of the transverse links, then a separate, second stabilizing transverse link is unnecessary, and one transverse link suffices.

It will be appreciated that the distance between the upper pivot axes 11 and 12 is greater than the distance between the axes of pivot hinges 13 and 14, which in turn is greater than the distance between the axes of pivot hinges 15 and 16. In the illustrated embodiment, the two upper transverse link members 7 and 9 are pivoted to the frame member 2 on two different pivot axes 8 and 10. The pivot points 8, 10 and 17 thus form the vertices of an isosceles triangle. It will be appreciated that in other embodiments, see e.g. Figs. 7-9, such a triangle formed by these pivot axes is not necessarily

an isosceles triangle. Since the upper link members 7 and 9 are not rigidly connected together, it will be appreciated that the distance between the film hinges 13 and 14 is not constant during rocking of the head 1. Nevertheless, it remains smaller than the distance between the pivot points 11 and 12 throughout the range of movement of the head 1. Similarly, the distance between the film hinges 13 and 14 remains greater than the distance between the film hinges 15 and 16 throughout the range of movement.

It will also be appreciated that in this embodiment the pivot axes associated with the right-hand support arm 5, i.e. axes 11, 13 and 15, lie in a first common plane (that is, as viewed in transverse cross-section as in Figs. 1-2, they appear co-linear). Similarly, the pivot axes 12, 14 and 16 associated with the left-hand support arm 4 lie in a second common plane. The first and second common planes are inclined at an acute angle which varies slightly during the rocking action of the head 1. However, it is not essential that these three pivot axes 11, 13, 15 or 12, 14, 16 be coplanar (appear co-linear), see e.g. Figs. 7-9 or Figs. 10-12.

Figure 2 shows the mechanism in its central position, where the head 1 is located at its central position. In this position, the distance between the film hinges 13 and 14 is at its maximum.

Figure 3 shows a perspective view of the mechanism of Figures 1 and 2.

In the embodiment of Figures 1 to 3, the head 1 can pivot by an angle of ± 9.5°. Figure 4 shows a modification of the design which allows the head to pivot by ± 13.5°. This is achieved by enlargement of the lower transverse link member 6 and corresponding adjustment of the lengths of the upper transverse link members 7 and 9, as will be explained in more detail hereinafter.

Figures 5 and 6 show an intermediate design where the head 1 is able to rock by ± 12.5°.

Apart from these modifications shown in Figures 4, 5 and 6, further modifications will occur to those skilled in the art on the basis of the above

disclosure. For example, the use of film hinges is not essential. These could equally be replaced by pin hinges, as shown in Figures 7 to 21. Moreover, although it is thought essential to provide two transverse stabilizing link members 7 and 9 which are articulated relative one another (that is, they move relative to one another) to avoid the mechanism locking up, it is not essential that these should be pivoted at spaced pivot points. It would be equally possible for the transverse stabilizing link members 7 and 9 to be pivoted on the shaver body 2 at a common axis as shown in Figures 10 to 12. It would even be possible for the transverse link members 7 and 9 to cross over each other or over the central plane, such as shown in Figures 7 to 9. For example, with reference to Figure 7, the left hand side of link 7 is attached to the frame at a location further to the left than the location at which link 9 is attached to the frame.

Figures 7 to 9 also demonstrate that the points of attachment of the stabilizing links 7 and 9 to the support arms 4 and 5 may be at differing distances from the head 1.

Figures 13 to 15 show a simplified embodiment essentially equivalent to that of Figures 1 to 3, but with pin hinges replacing the film hinges.

Figures 16 to 18 demonstrate that the main transverse link member 6 may be located between the head 1 and the transverse stabilizers 7 and 9.

Figures 19 to 21 demonstrate that it is even possible for the two stabilizers 7 and 9 to be positioned respectively above and below the main transverse link member 6.

Figure 22 shows a schematic representation of a linkage mechanism according to an embodiment of the invention exemplified by that in Figs. 1 to 3 or Figs. 13 to 15, in which the dimensions of the various components of the mechanism are indicated. The Figure also shows in phantom line a series of positions adopted by the mechanism as it rocks from one extreme position to the other. During this motion of about ±19.5 degrees (38.94° included angle) of travel of the virtual upper triangle (sides of 15mm) about the virtual pivot axis, the virtual pivot axis, whilst remaining on the central plane of

symmetry, moves vertically by a distance of 0.3 mm. In the embodiment shown in Figure 23, where the dimensions of the individual components are slightly different, the virtual pivot axis moves vertically by a distance of 0.37 mm over an amount of travel of about ±14.5 degrees (28.96° included angle) of the upper virtual triangle (sides of 20mm). In the embodiment of Figure 22, the top arm, meaning the distance from the virtual pivot to the point of attachment of each support arm, has a length of 15 mm. In Figure 23, the top arm has a length of 20 mm. The bottom triangle determined by the main transverse link (10 mm) is the same in each of Figures 22 and 23, and is rotated through the same ± 30 degree of travel (60° included angle) . The upper virtual triangle in Figure 23 is referred to as "twice the size" of the lower triangle (20:10), whereas the upper virtual triangle in Figure 22 is referred to as "one-and-one-half the size" of the lower triangle (15:10).

The following table gives the height of the virtual pivot from the point of attachment of the main transverse link to the frame for a succession of angles of rotation of the main transverse link member. The table gives these values for the embodiments of Figures 22 and 23.

Angle of rotation of bottom triangle	Height of Apex of top triangle from apex of bottom triangle (mm)	
	Top arm = 15 mm	Top arm = 20 mm
0	31.3114	34.1635
5	31.3193	34.1735
10	31.3430	34.2034
15	31.3827	34.2534
20	31.4393	34.3237
25	31.5136	34.4148
30	31.6067	34.5268

It will thus be appreciated that the slight amount of deviation during rotation of the virtual pivot axis from its at-rest neutral position is used as a design trade-off considering the size of the envelope within which the linkage can be contained and the desired amount of arc travel. It is noted that when using a conventional fixed pin bearing (physical axis) or a shell-like bearing (virtual axis) to support a shaving head about a pivot axis close to the shaving plane, such a pivot axis remains theoretically unchanged through the arc of travel. The present invention's linkage generates a dynamic virtual pivot axis that moves outward towards the skin surface only a small, finite amount and is acceptably close to a static pivot axis.

At least for upper virtual triangles whose sides have lengths that are longer than the lengths of the sides of the lower triangle, then, as between two differently sized upper virtual triangles (cf. Figs. 22 and 23), the smaller the upper virtual triangle is (e.g. Figs. 22), then the greater is the amount of arc travel that it can undergo for a given amount of arc travel of the lower common link, thus reducing overall width of the linkage in the handle, thus resulting in a spatial economy of packaging.

Figures 24 to 28 show schematic representations of further variants of the linkage mechanism according to the invention. It may be seen that in

each case the head supported by the support arms is able to rotate by a total angle of approximately 25° whilst the virtual pivot is substantially static and moves only very slightly in a vertical direction. Whilst in most of the illustrated embodiments the angle included between the two top arms is equal to the angle subtended by the two limbs of the main transverse link member, Figure 28 shows that this is not necessarily the case. Here, the angle subtended by the two top arms is 120° whilst the angle subtended by the two limbs of the main transverse link member is 90°.

Next, the design process by which a linkage mechanism for use in a hair removal device can be generated will be described with reference to Figure 29. Here it is assumed that the depilation appliance, e.g. a shaving head, will be mounted on a handle which provides only limited space to contain the mechanism. Accordingly, the first step 291 in the design process is to determine the maximum space envelope for the mechanism within the handle. Next the details of the head must be determined including its maximum size, desired reaction response mode and the desired amount of swing (step 292). The required position of the virtual pivot relative to the active components of the depilation apparatus, e.g. shaving units, will then be determined (step 293). With this basic information, the main transverse link, referred to in Figure 29 as a lower triangle, will be drawn in its rest position at a size as large as possible (step 294) whilst nevertheless ensuring that it remains within the maximum space limits when rotated (The lower link could even be a straight bar rather than a triangle, but the flatter the link then, it is believed, the less it will react to horizontal forces but the more it would react to downward forces). Next the upper virtual triangle is drawn in its rest position having the virtual pivot as its apex (step 295). This triangle will preferably have a 90° included angle to ensure equal response to horizontal loads (associated with drag on the skin) and vertical loads (associated with pushing into the skin). The upper and lower triangles are then joined by straight links which represent initial placement of the support members (step 296). The top virtual triangle is then rotated by the required

amount, e.g. ± 20°, ensuring that the virtual pivot remains on the vertical axis (step 297). Using the motion generated by the mechanism, the locus of a point on each connecting link is then plotted (step 298). An arm is then drawn from a centre of each locus to its origin in order to generate the stabilizing transverse link (step 299). The designer has the freedom to choose a location along the extent of the vertical link where it will be spatially convenient to place the stabilizing link, and this location does not have to be the same on both vertical links. Now that the basic mechanism has been determined, the shape of the vertical links can be redesigned (step 300) as the finished support member to ensure that they do not move outside the maximum space envelope. It will be appreciated in steps 294 and 295 that as between two different arrangements generating two differently sized "upper virtual triangles", one larger and the other smaller, then the smaller one will yield less "displacement error" , or in other words the smaller the displacement of the virtual pivot axis during arc travel becomes. It is also not required that the lower triangle and the "upper virtual triangle" be similar triangles (reference is again made to Figures 22 and 23). In contrast, it is noted that in prior art four-bar links, the several transverse links or bell cranks arranged in ladder-like arrangement were constrained to be congruent to one another.

Figure 33 is a view corresponding to Figure 3, but where the depilation head 1 is configured as an epilator head for plucking hair mounted to the linkage in place of a shaver head. The heads can be interchangeable, as for example by changing the hair removing elements attached to the upper surface of head 1 as is known in the art such as in U.S. Pat. 5,611,804 (Heintke et al.) assigned to Braun Aktiengesellschaft and incorporated herein by reference, or by interchanging the type of head 1 attached to the support arms 4,5 of the linkage mechanism. Further views of the epilator are shown in Figs. 34 and 35.

The linkage of the present invention is preferably oriented as shown in Fig. 1, but it is also possible to orient it ninety degrees thereto to generate a end-to-end pivoting of the head, as shown in Figures 36, 37 and 38.

Further modifications will occur to those skilled in the art. All such modifications are intended to be covered by the following claims, irrespective of their summary in the claims or their back references.

Without limiting the scope of the invention, reference numbers used herein are listed:

Table of Reference Numerals

1.	Rocking head	20.	Rivet
2.	Shaver body	21.	Rivet
3.	Linkage mechanism	22.	Support member
4.	Support arm	23.	Support member
5.	Support arm	31.	Short hair cutter
6.	Main transverse link	32.	Short hair cutter
7.	Stabilizing transverse link	33.	Long hair cutter
8.	Pivot axis	71.	Side member
9.	Stabilizing transverse link	72.	Side member
10.	Pivot axis	73.	Transverse link member
11.	Upper pivot axis	74.	Transverse link member
12.	Upper pivot axis	75.	Central plane
13.	Pivot hinge	81.	Pivot axis
14.	Pivot hinge	82.	Pivot axis
15.	Pivot hinge	83.	Pivot axis
16.	Pivot hinge	84.	Pivot axis
17.	Mounting pivot	85.	Pivot axis
18.	Support member	86	Pivot axis
19.	Rivet		